Evaluation of NCAR CAM3 Water Vapor with Modeled and Observed AIRS Cloud-Cleared Radiances

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Objective:

Use modeled and observed cloud-cleared AIRS radiance spectra to evaluate water vapor and temperature simulation in CAM3

Data:

AIRS V4 L1B radiance spectra

- Channels with non-zero QA flags were excluded
- Only two cross-track scan angles nearest nadir (+/- 0.5 deg) were used in spatial averaging
- Cloud-cleared spectra defined as having channel 857 (943.2 cm^{-1}) brightness temperature within 5 K of local AIRS L3 surface temperature (over ocean)
- Radiances averaged over low and mid-latitude ocean regions (selected to avoid cloudiest areas)

AIRS V4 L3 water vapor, temperature, surface temperature

- Focus on 300 mb and 500 mb

Models:

NCAR CAM3 (Community Atmosphere Model)

OSS (Optimal Spectral Sampling - AER)

- Used to simulate clear sky AIRS radiances in CAM3

RRTMG/McICA (Broadband LW and SW radiative transfer - AER)

- Used as replacement radiation model in CAM3
- McICA is stochastic technique for handling cloud overlap and sub-grid cloud variability (Pincus et al., 2003)

GCM Simulations:

(1) CAM3_OSS

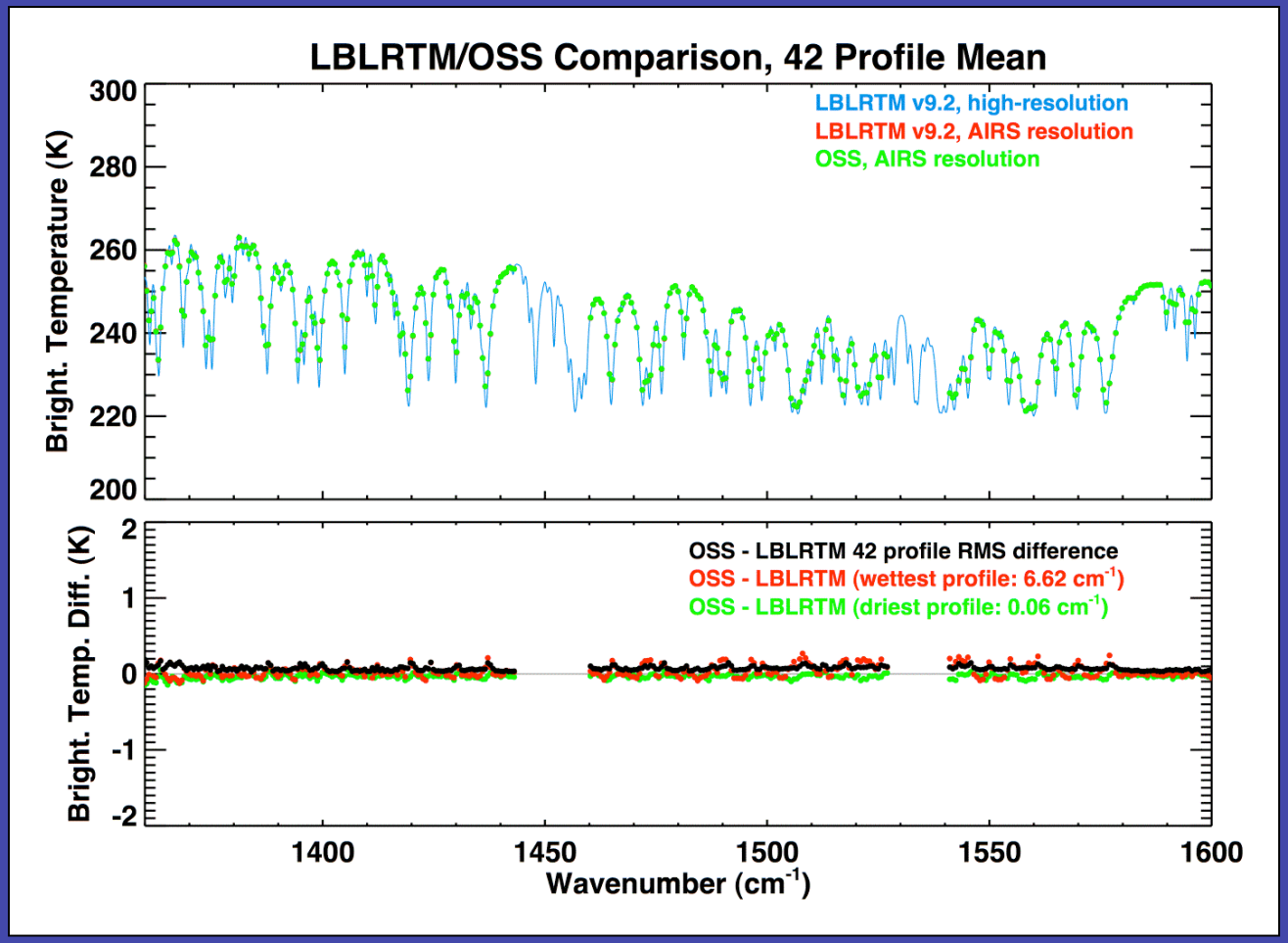
(2) CAM3_RRTMG/McICA_OSS

- Additional output: 6-hourly BT spectra in three intervals:
  - Temperature: 700-750 cm^{-1}
  - Window: 937-952 cm^{-1}
  - Water Vapor: 1340-1570 cm^{-1}
- Cloud filtering: Exclude clear sky spectra where model has cloud fraction > 0.3 above 700 mb

Initial Step: (presented to AIRS ST in Dec 2004)

Compare OSS to LBLRTM for variable set of profiles

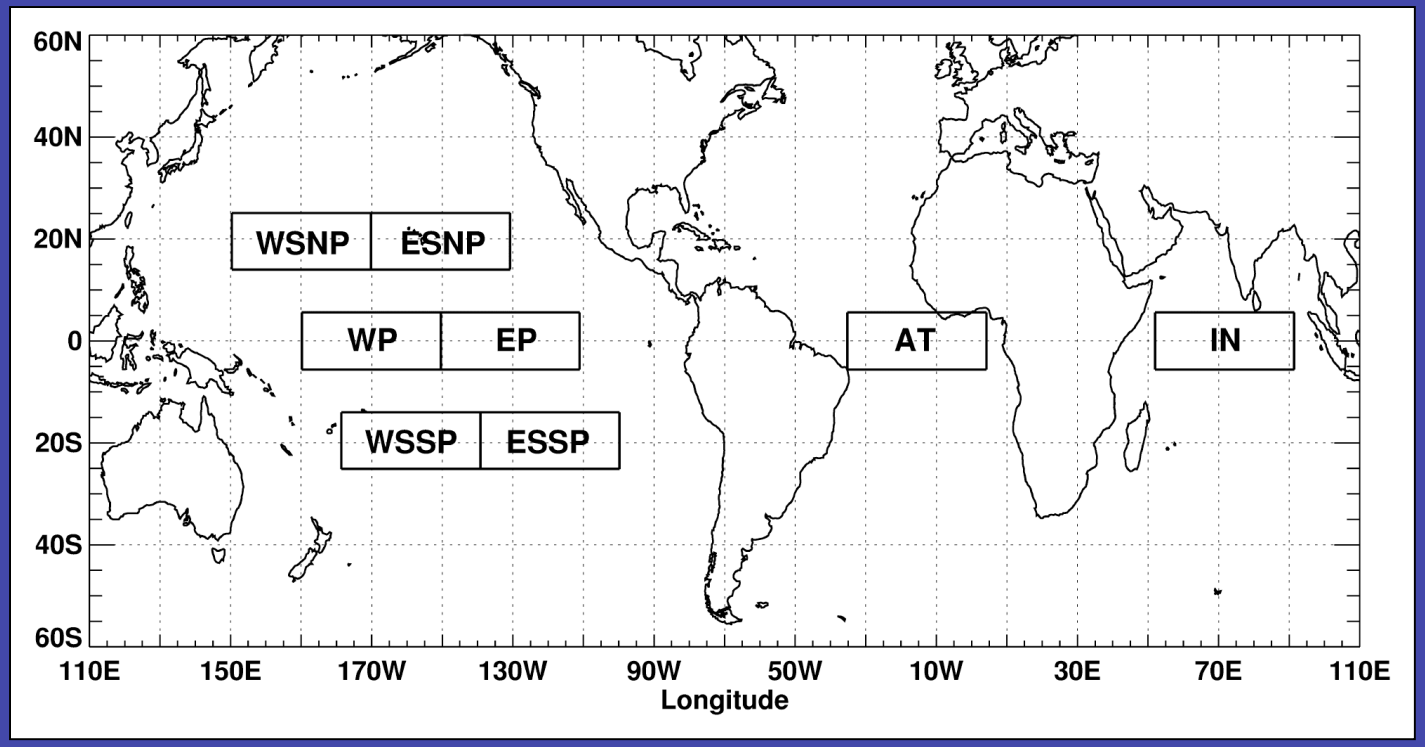
OSS within 0.2 K of LBLRTM across water vapor band



GCM Simulations: (January and July 2004)

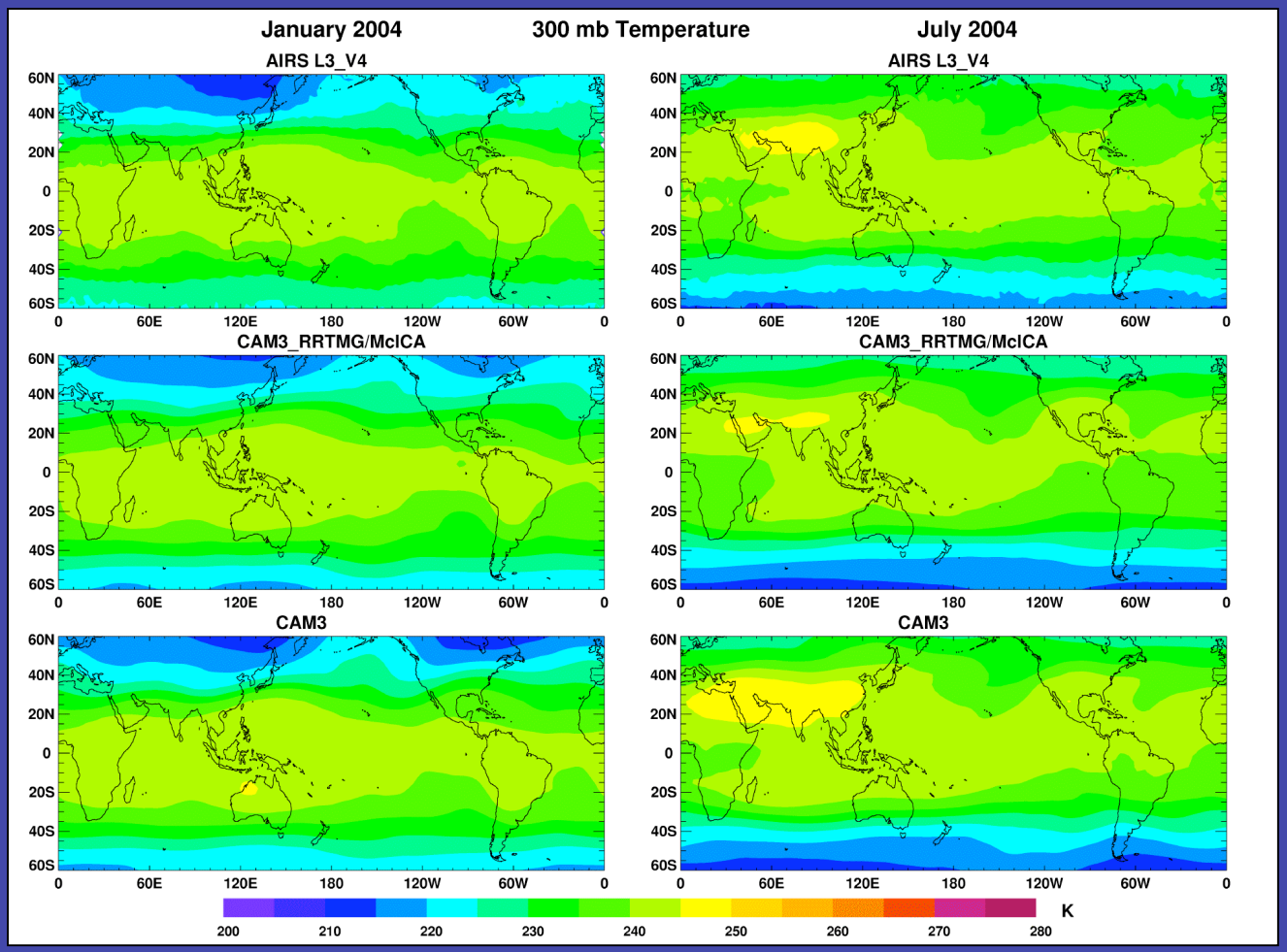
Ocean regions analyzed

- Exclude cloudiest eastern ocean and Warm-Pool areas
- Will focus on Pacific regions



Temperature:

300 mb, January and July 2004



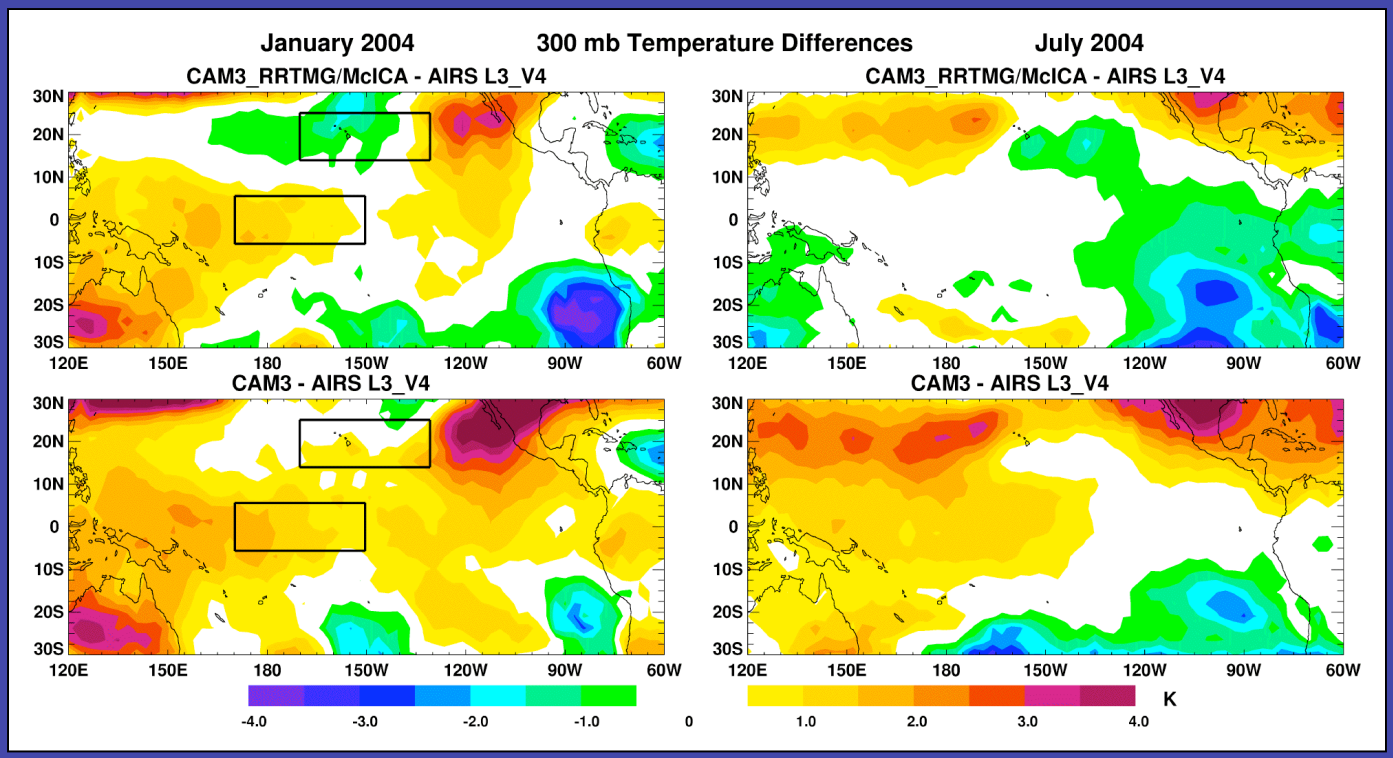
AIRS L3

CAM3_
RRTMG

CAM3

Temperature Differences:

300 mb, January and July 2004

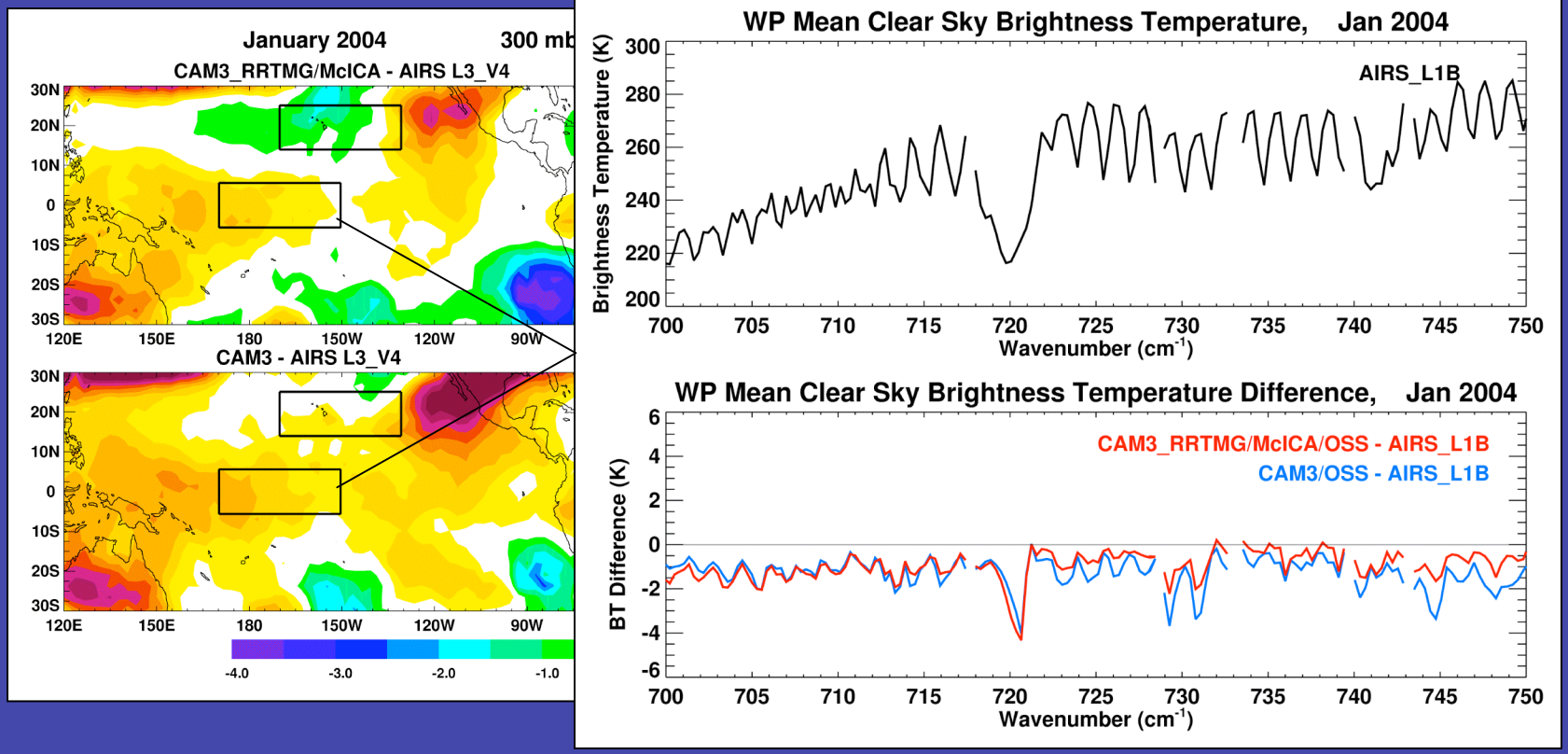


CAM3_ RRTMG - AIRS

CAM3 - AIRS

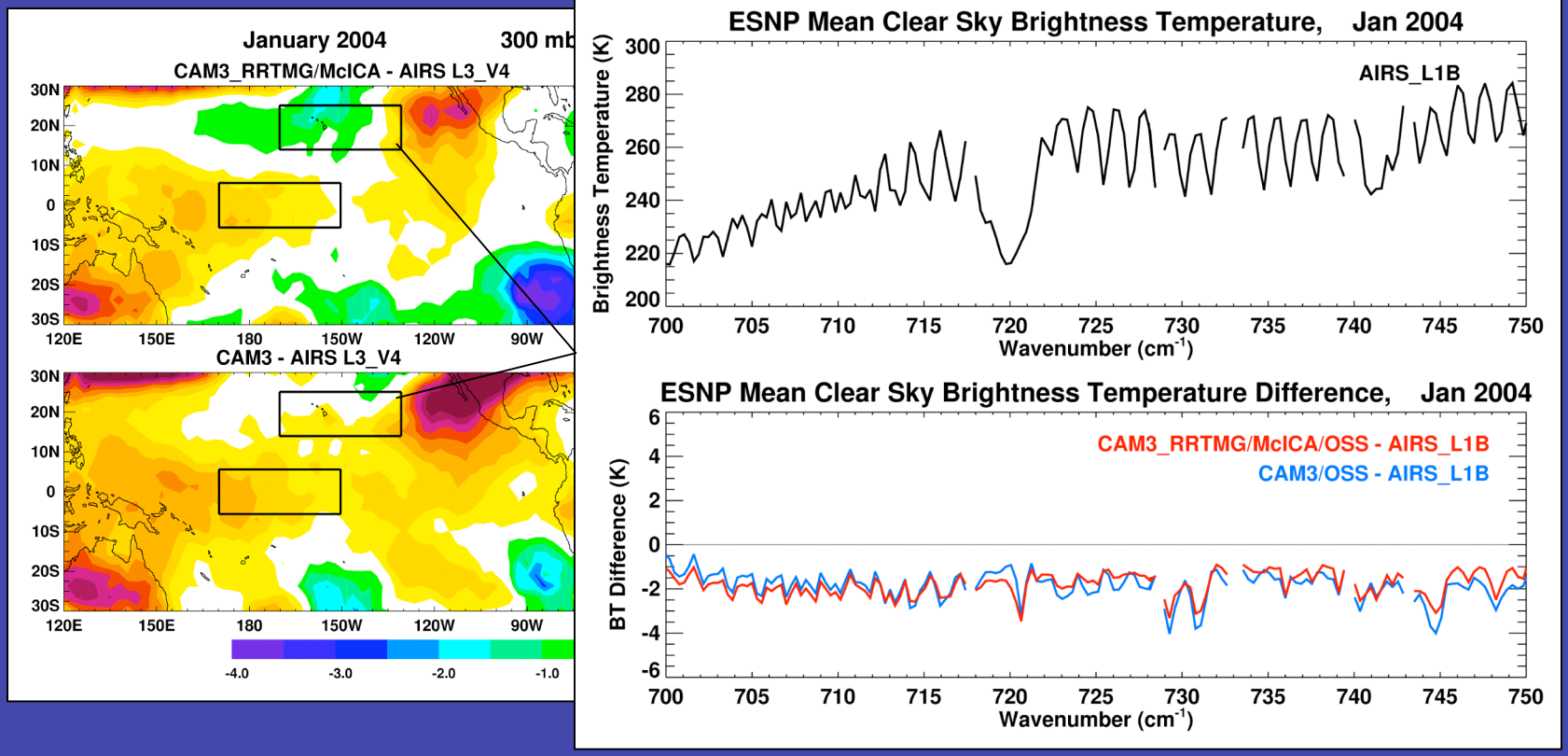
Temperature and Mean Spectral Differences:

300 mb, January 2004



Temperature and Mean Spectral BT Differences:

300 mb, January 2004

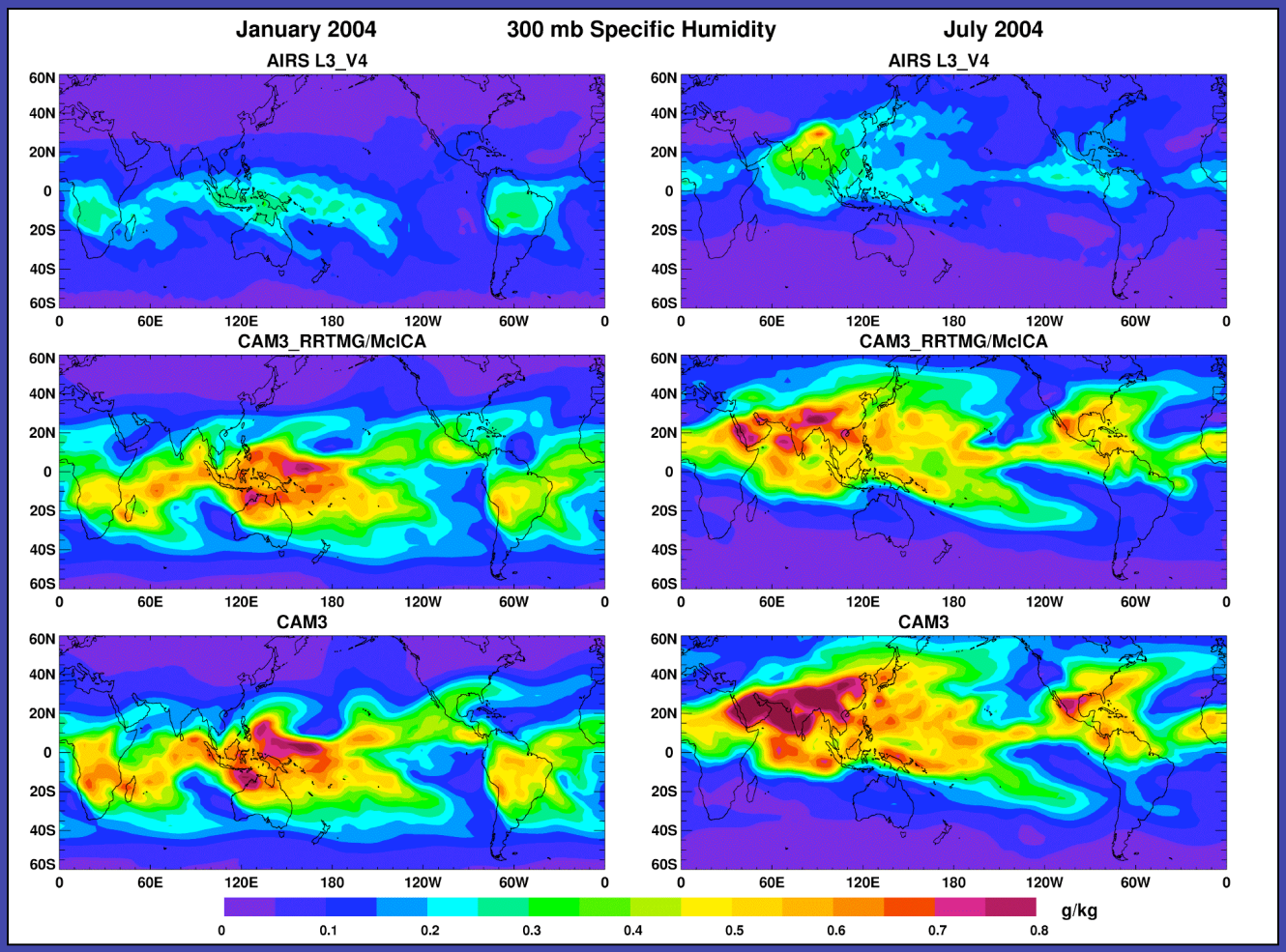


From LBLRTM:

2 K decrease in tropospheric temperature ~ 1 K decrease in BT in this band

Water Vapor:

300 mb, January and July 2004, specific humidity (g/kg)



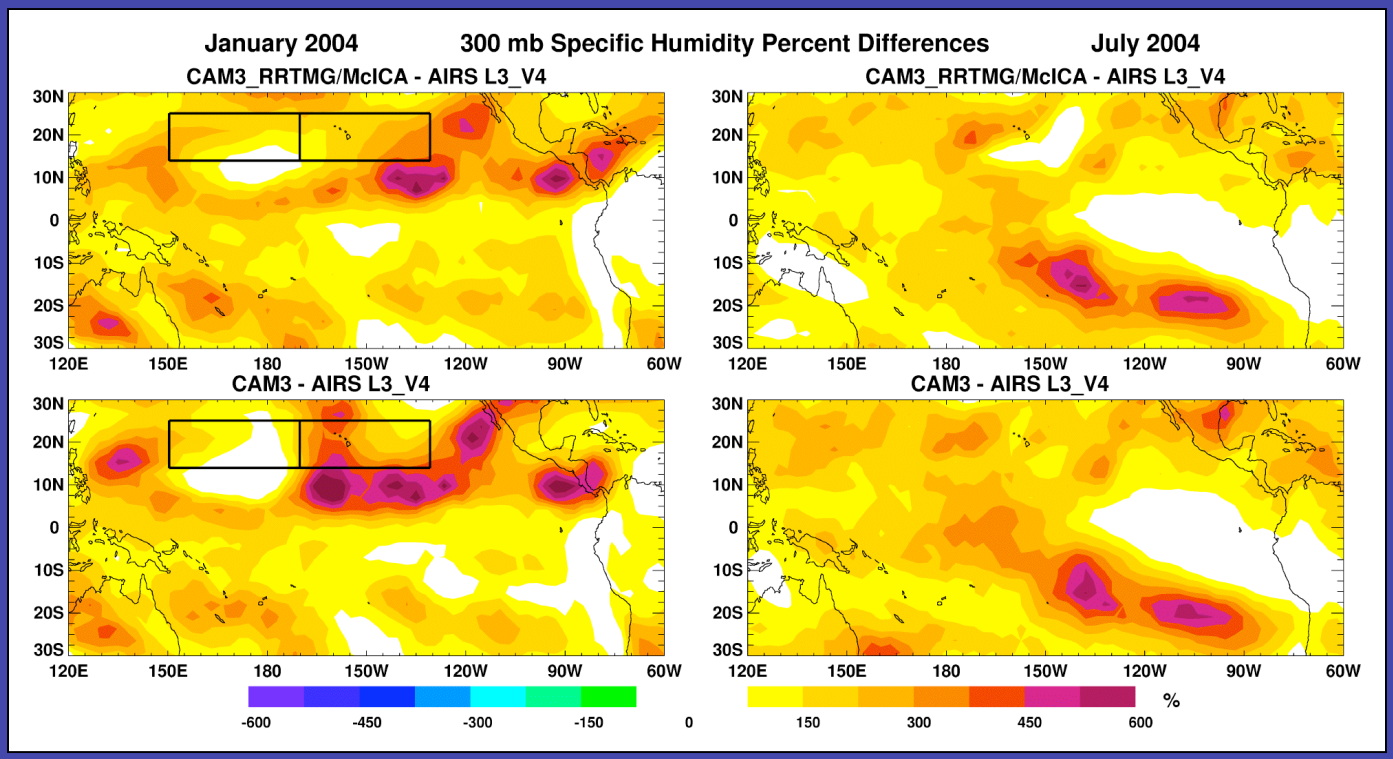
AIRS L3

CAM3_
RRTMG

CAM3

Water Vapor Differences:

300 mb, January and July 2004, percent

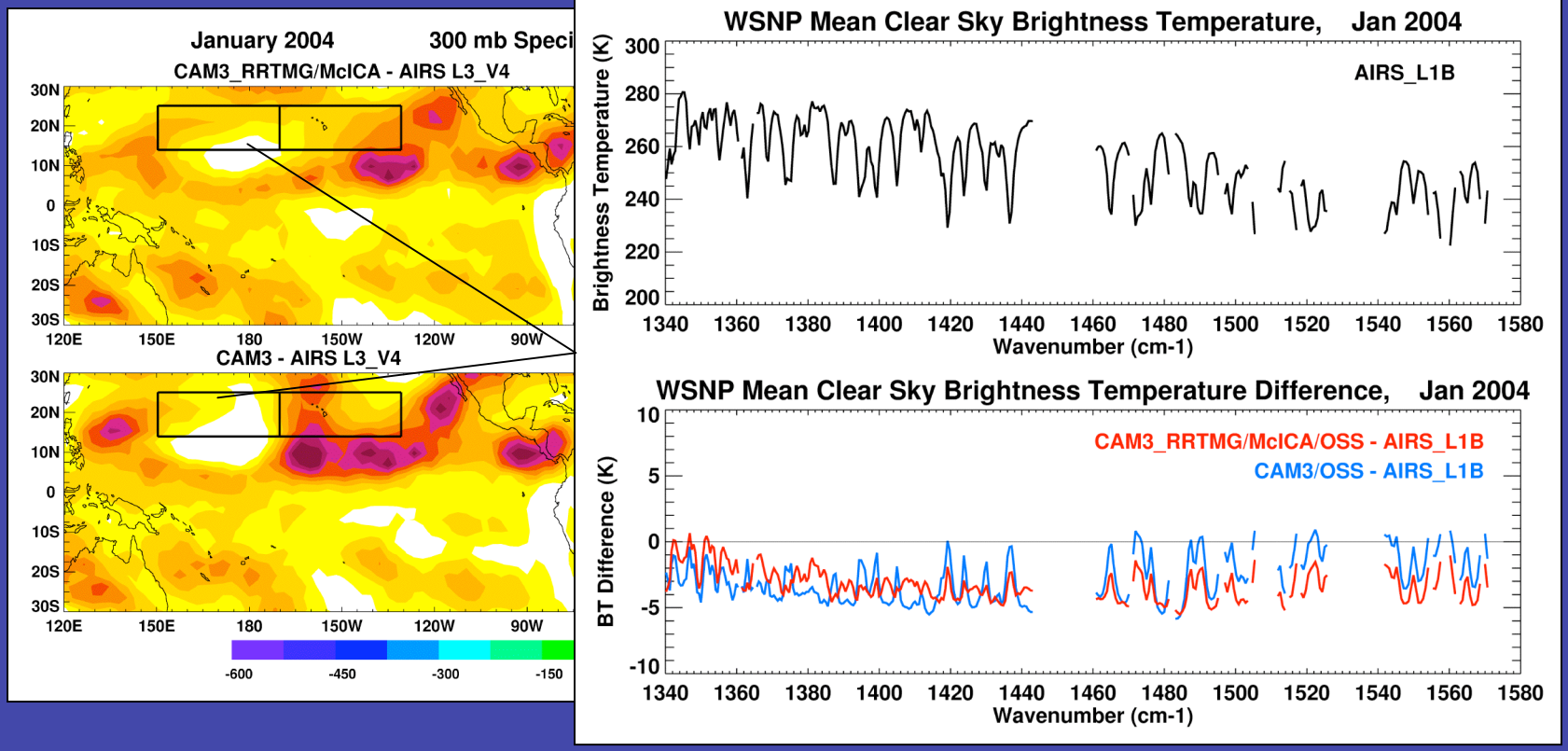


CAM3_ RRTMG - AIRS

CAM3 - AIRS

Water Vapor and Mean Spectral BT Differences:

300 mb, January 2004

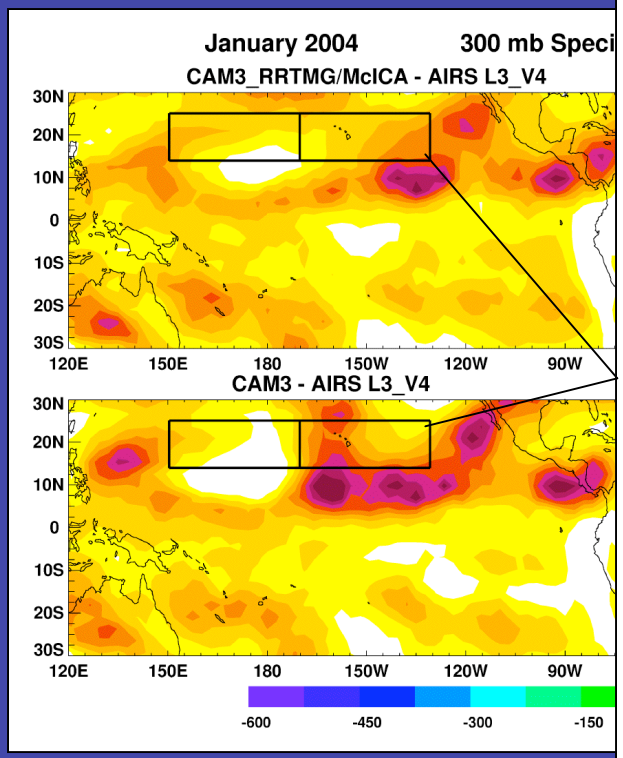


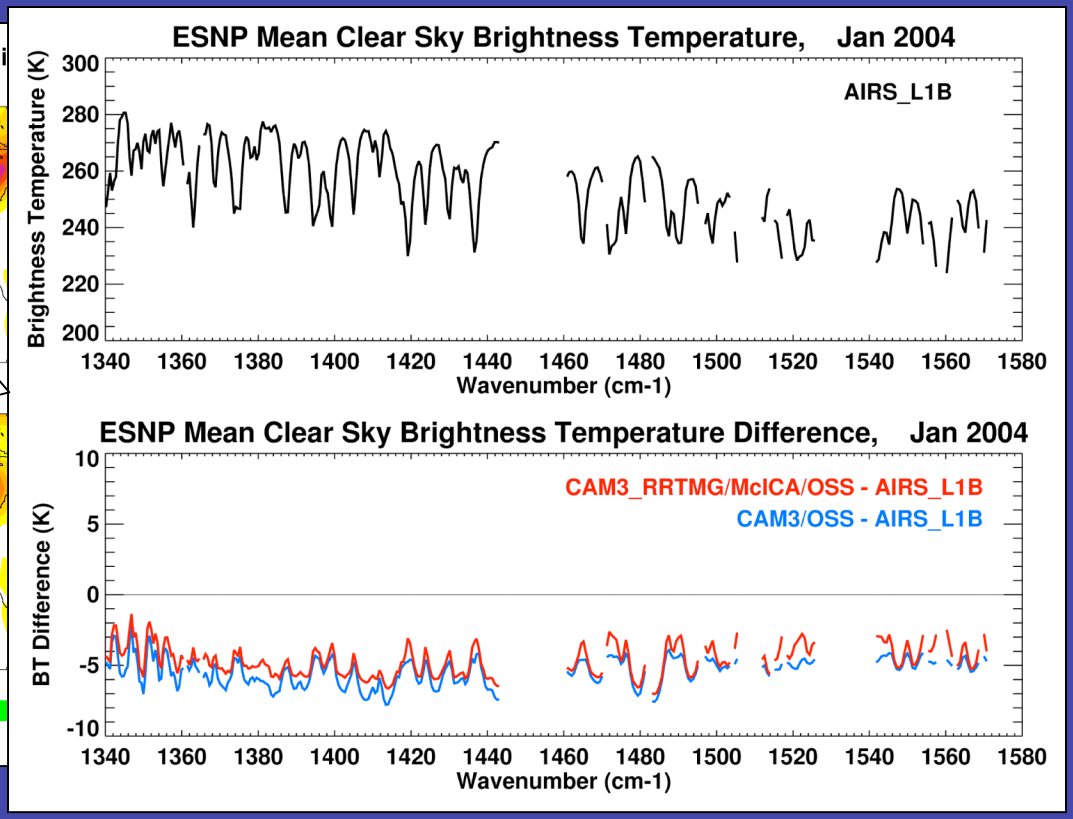
From LBLRTM:

15% increase in water column ~ 1 K decrease in BT in this band

Water Vapor and Mean Spectral BT Differences:

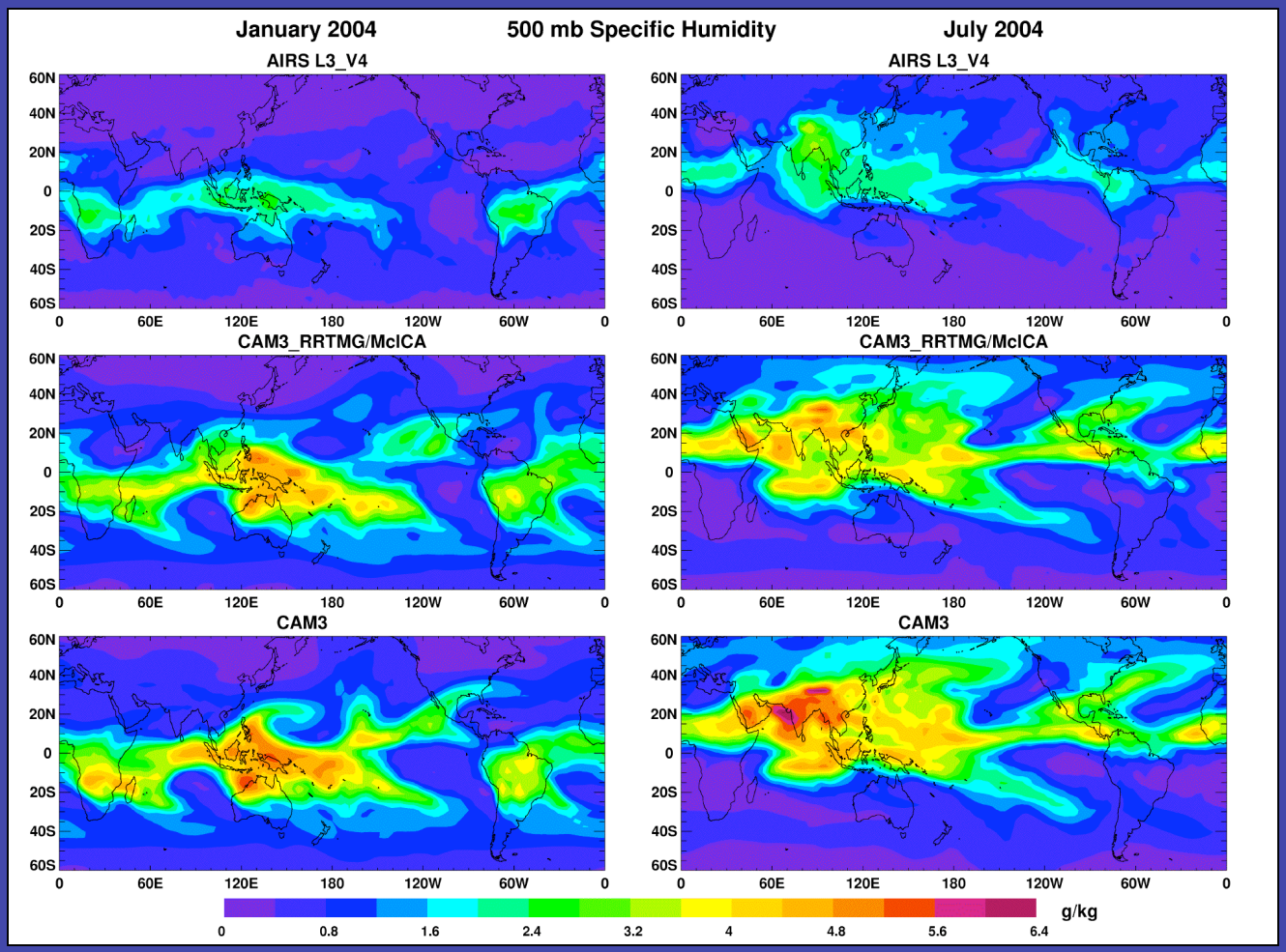
300 mb, January 2004





Water Vapor:

500 mb, January and July 2004, specific humidity (g/kg)



AIRS L3

CAM3_
RRTMG

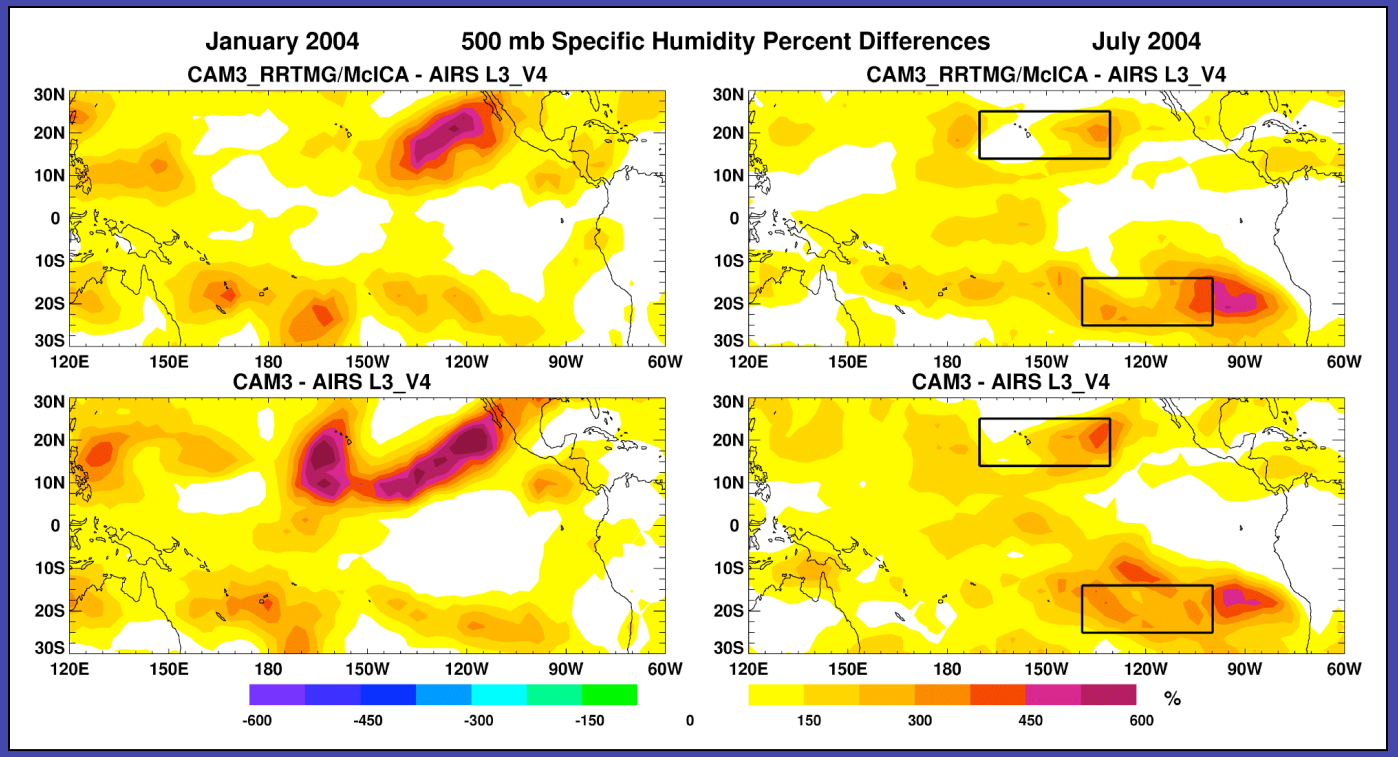
CAM3

Water Vapor Differences:

500 mb, January and July 2004, percent

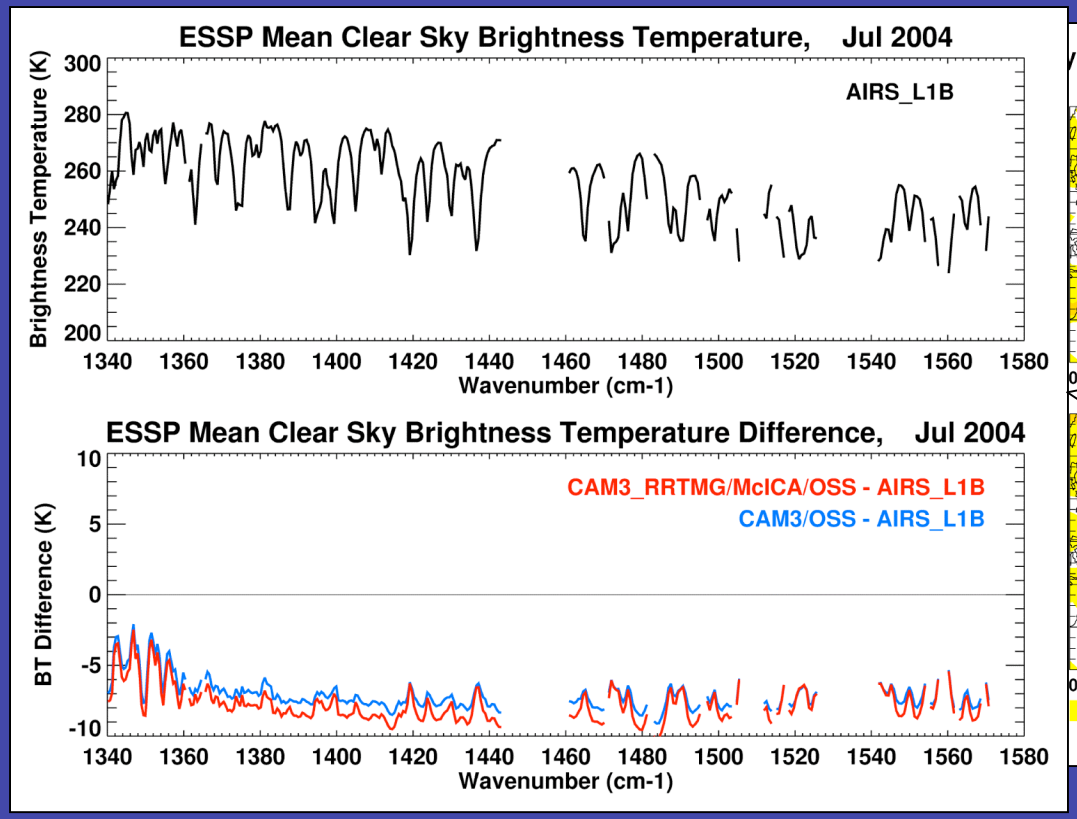
CAM3_ RRTMG - AIRS

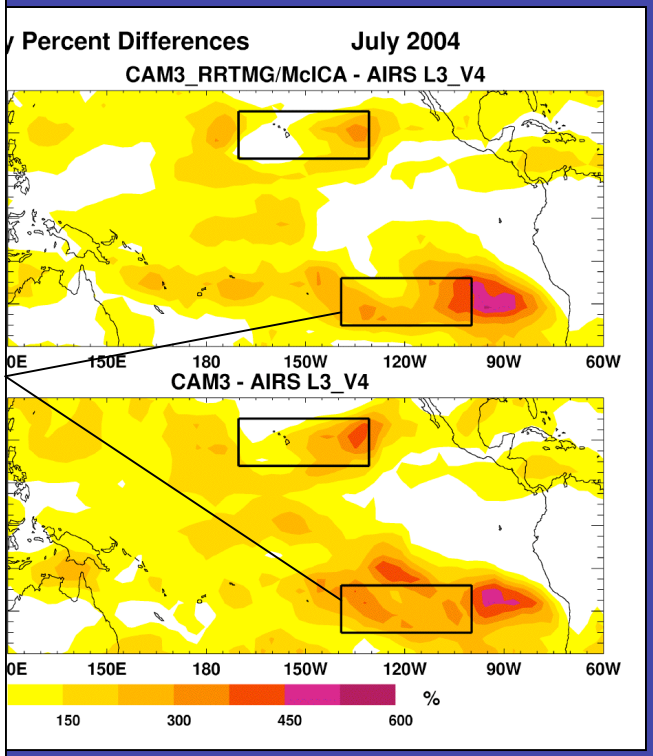
CAM3 - AIRS



Water Vapor and Mean Spectral BT Differences:

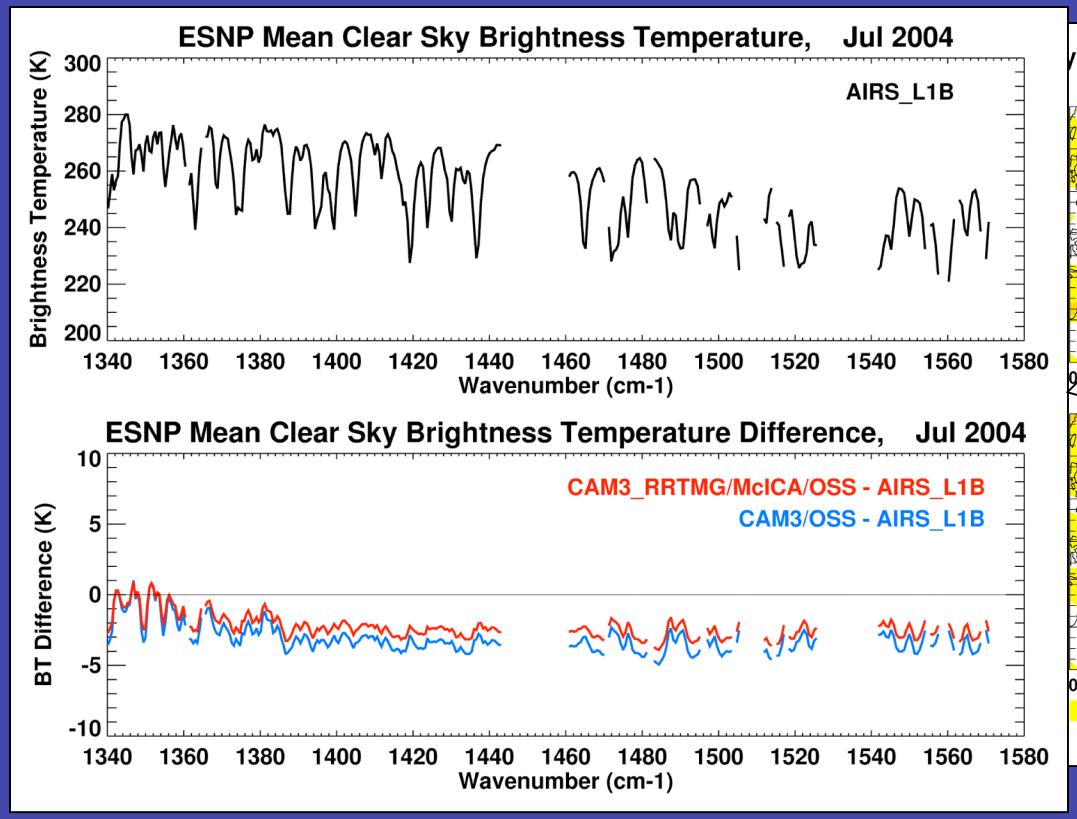
500 mb, July 2004

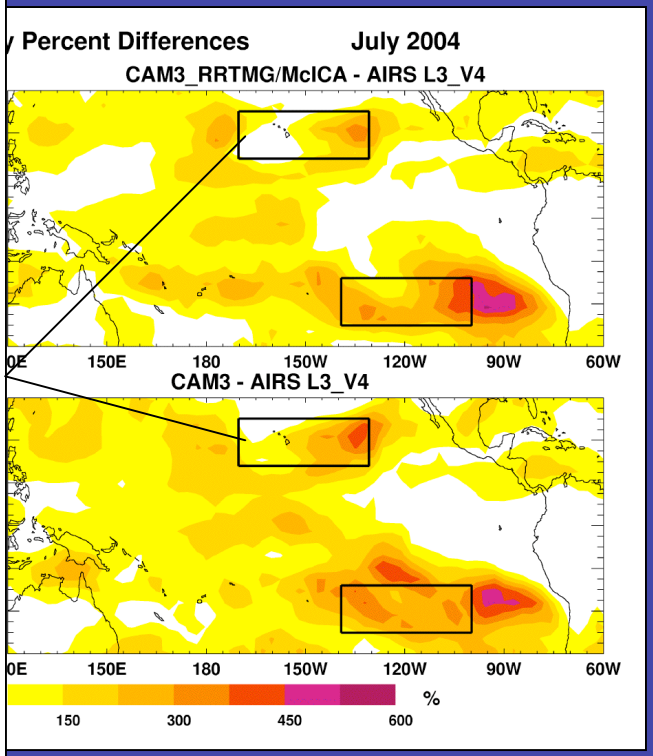




Water Vapor and Mean Spectral BT Differences:

500 mb, July 2004





Summary:

- Using OSS to model clear sky AIRS spectral radiances in CAM3
- Comparing CAM3_OSS and AIRS radiance differences to evaluate model water and temperature
- Provides a relative method to validate AIRS L3 retrieved atmospheric state?
- Spectral BT differences in temperature band show CAM3 1-2 K cooler relative to AIRS L1B; comparison of CAM3 and AIRS L3 temperatures are closer
- Spectral BT differences in water vapor band show significant moist biases of 50-100% or more in CAM3 in some regions and levels; model moist biases even larger in comparison of CAM3 and AIRS L3 water vapor
- Results in some regions are sensitive to impact of RRTMG in CAM

Future Work:

- OSS with multiple scattering now available
- Use OSS to model cloudy radiances from CAM3 output
- Compare to AIRS cloudy radiances